Improved Oil Cooling - Or, the Thrill of Victory, and the AGONY of DEFEAT!

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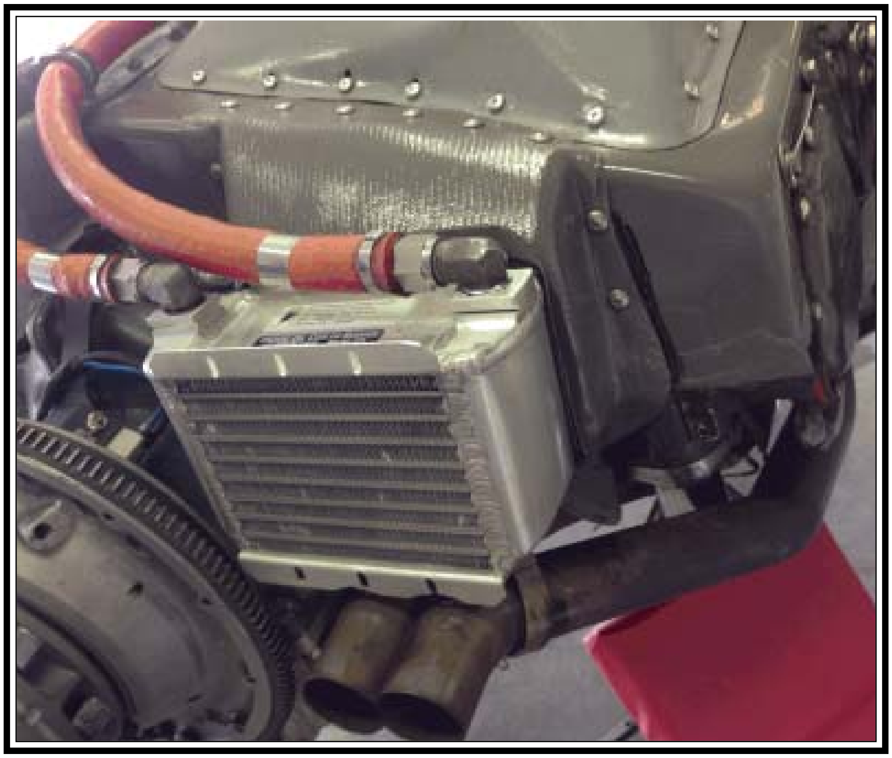
The Problem:

I've been flying my IO-360 powered "Standard" Velocity RG for around 16 years and 1100+ hours now, and it's been through many changes. Along the way, I've gone through numerous cooling system changes including variations on armpit scoops, rooftop NACAs, and all kinds of plenum modifications. Through tons of sandpaper, sweat and toil, I've been able to get to where my cylinders are cooling extremely well with what seems to be a very efficient low drag setup. The one cooling challenge I've never stepped up to was to work on oil cooling, which has always been sorta-kinda OK... typically running around 195-205 in cruise. I say sorta-kinda OK because, while the cruise temps are acceptable, I could always easily cook my oil in a long, full power climb.

The basic oil cooler problem I have is that I've got the original Velocity plans oil cooling, which uses an 11 row oil cooler mounted in the nose, fed by a sorta-kinda NACA. There are numerous issues with this implementation... the sorta-kinda NACA is mounted on the curved nose which means the maximum NACA ramp angle of about 7 degrees is FAR exceeded, and because for it's width this "NACA" is far too short. It really can't function as a NACA at all. Oil tests show that the airflow enters the end pocket directly, dams up, and spills over the side (creating detached air down the entire side of the airplane and lots of drag). Another issue is that the input and output tubes for the cooler clock in at around 20 feet in length each - yes, 40+ feet total - and worse, they're both co-located in the same small conduit, ensuring plenty of heat transfer between the hot and cool side. Not good!

So, in net, I have poor oil cooling performance and a significant drag penalty.



new smaller cooler fed from high pressure cooling plenum

It's only redeeming value is that it provides some cabin heat via a flapper valve. But, I'm a Minnesotan and I'm here to tell ya, it doesn't come close to minimum requirements on a cold day. So, despite my wife Ali's concerns in loosing even that small amount of heat, I figured it's worth trying to do better.

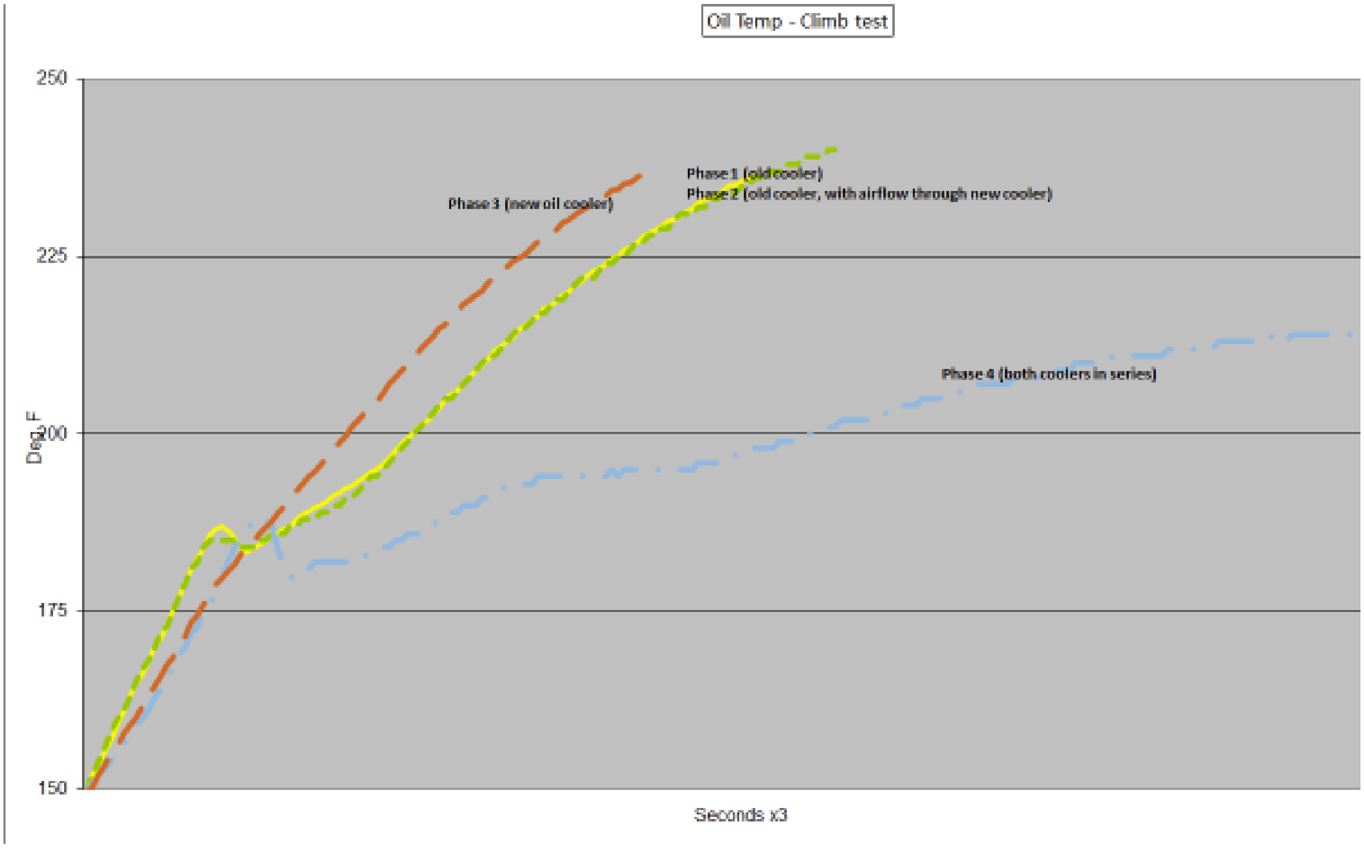
My Idea:

Because my CHTs have been running consistently very cool (with my highest barely approaching 340 under stressful conditions), I figured, Gee! Why don't I use some of that cylinder cooling capacity to cool my oil! This could be a real win-win! I could (in theory) get rid of my nose mounted cooler and it's associated drag, get better oil cooling, and run faster and cooler, all at once!

I set out to mount a new oil cooler on the back of the plenum, between the #2 cylinder and the flywheel/prop. It turned out that I could squeeze a 9 row cooler in there, and after significant discussion with the kind folks at Pacific Oil Cooler, I felt comfortable that, in theory, it should work. Wow... if I had any idea how much work this would all be!

Implementation:

Implementing this was about what one would expect. First, I blocked out the cooler mount using foam, which was then glassed to make an appropriate transition for airflow from the back of the plenum, just off the #2 cylinder, to the new cooler. I made this cooler mount very stiff to ensure it was sturdy enough to take the vibrating mass of the cooler and distribute the load appropriately onto the plenum. Adequate clearance between the flywheel and the cowling were key concerns. In the end, I had to gain a little space in the cowling which I did by cutting a longitudinal slit into the cowling along a line from the cowling rear about 16 inches forward, well past the interference point (which turned out to be where the right 90 degree oil cooler fitting was. I then put a spacer over the cooler where it interfered with the cowl, which opened up the slit I had cut to the appropriate width. Finally, I applied one ply of bid to the outside, and two to the inside, to repair the slit. After finish, paint,



and polish, the cowl was appropriately bigger in the right spot.

I didn't immediately cut the hole between the plenum and the new cooler... I wanted to take good before/after data first.

In god we trust, all others bring DATA:

I'm an engineer in my working life, and I really wanted to apply good engineering practice to this change to ensure I could see with confidence whether I had really improved my oil cooling or not. That meant doing what we call good DOS: Design Of Experiment. So, to ensure good DOS I planned testing in three phases (which, as you'll see, turned out to be four phases).

All data was collected using a **standard flight profile**, which basically netted out as:
- Full throttle, 2700 RPM (I' have a constant speed MT prop)
- Climb straight ahead at 95 knots IAS... avoid turning, which could change the airflow into either cooler.
- Keep climbing until oil temp reached 240 degrees Fahrenheit, or 12,500 feet, whichever came first
- Record oil temperature along the way, and the peak altitude reached. I used my Dynon EMS-D10 and EFIS-D10A for this.

The experimental phases I planned were:
- **Phase one**: collect data on the existing, unmodified, nose mounted cooler
- **Phase two**: cut the hole in the plenum allowing airflow through the new cooler - but continue using the old, nose mounted cooler. This was to ensure that I hadn't created unmanageable problems with my cylinder head temps.
- **Phase three**: disconnect the old cooler, and connect the new one.

Using the above Design Of Experiment allowed me to ensure I could do more than a hand waving argument to say either, "it works!", or "RATS!". After all the years of trying to con-

vince myself I'd solved a problem without good data, I wanted to apply the most important thing I ever learned, what I use every day at work - the scientific method we all learned in the 7th grade. I'm happy I did!

RATS! ... or ... the AGONY of DEFEAT!

Well, it turned out that the new cooler had less capacity than the old... RATS! A hard pill to swallow after all that work! Here's the data:

Discussion:

Clearly, as my dad used to say, "that dog just don't hunt"... and wow... after all that work... that kinda hurts! As you can see, the oil temperature increase over time (i.e., the slope of the line), is much greater with the new cooler setup than the old. In table form it looks like this:

	Outside Air Temp		Alt @	Oil T Inc 190->240	Avg. Peak Altitude	Average Slope
	Takeoff	Peak Alt	240 F	Deg/Min		Deg/Min
Ph 1 Flt 3	74	52	8809	12.345	9041	12.77
Ph 1 Flt 4	79	49	8868	12.82		
Ph 1 Flt 5	73	51	9447	13.157		
Ph 2 Flt 1	79	54	9198	12.658	9198	12.66
Ph 3 Flt 1	79	60	7133	19.607	7905	15.43
Ph 3 Flt 2	82	56	7922	14.492		
Ph 3 Flt 3	78	57	8659	12.195		
Ph 4 Flt 1	73	41	N/A	3.61	12500	3.61

As you can see, the average altitude at which my oil temperature peaked with the old cooler was greater than 9,000 feet. The peak altitude at 240 degrees F with the new cooler dropped to less than 8,000. RATS!

Cylinder temps were remarkably unaffected. CHTs on 1,2 and 3 really didn't register much change at all. CHT 4 (on the cooler side, but forward, away from the new cooler) did increase by about 40 degrees, and now peaks at around 340-350 - which I still consider very acceptable.

So... what is Phase 4, you ask? Well, given that the new cooler couldn't get the job done by itself, I elected to put both coolers in series. That data is what I called Phase 4 and, as you can see, the extra capacity afforded by the second cooler completely solved the oil cooling issue - at significant cost, extra weight, and a GREAT deal of work! The only benefit is that I did indeed fix my oil cooling issue without adding any more drag.

Oh well... back to the drawing board. Next steps will be to measure the pressure differential across the new (and old) cooler ... perhaps there's still a way to make this work! Hmmm... If I can increase the delta P... and, winter is coming... I'll need a project!